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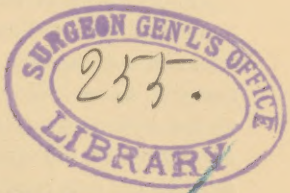

HYDRONAPHTHOL;

A NEW ANTISEPTIC.

By GEORGE R. FOWLER, M. D.,
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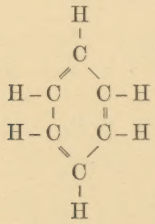
Hydronaphthol, the subject of the present article, has only recently been discovered, and this is believed to be its first introduction into surgical practice. It was in the belief that it would be found of value in the treatment of wounds that I began the investigation of its antiseptic properties in the early part of the present month, when my attention was called to the compound by Mr. W. J. Rigney, of New York, to whom I am indebted for the facts regarding its composition herewith presented.

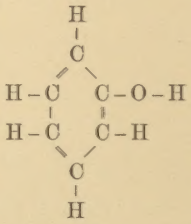
Hydronaphthol belongs to the phenol series, and bears the same relation to naphthyl, the hypothetical compound radical of naphthalin, that carbolic acid does to the compound radical phenyl. Thus, carbolic acid was formerly regarded as the hydrated oxide of phenyl. Hydronaphthol, considered in the same way, would be a hydrated oxide of naphthyl. The following formula will show the analogy:

Carbolic acid, $C_{12}H_5O$, HO;
Phenyl, $C_{12}H_5$
Hydronaphthol, $C_{20}H_7O$, HO;
Naphthyl, $C_{20}H_7$.

At the present time, however, these hypothetical compounds, phenyl and naphthyl, are considered as being obsolete, and not capable of existing. In fact, carbolic acid is regarded as an oxide of benzol, or as a benzol in which one of the hydrogens is substituted by one hydroxyl (O H). According to the graphic formula of Prof. Kekulé, this substitution occurs as follows:



Benzol.



Carbolic Acid.

In the aromatic hydrocarbons are found many isomerical substances. This peculiar identity in chemical composition, associated with varying physical properties, can only be accounted for by a difference existing in the arrangement of the atoms in the molecule. The graphic formula as above illustrated is well adapted for explaining the relations and properties of these aromatic compounds, of which benzol is the prototype. Thus, in all the monosubstitutions of benzol there is but one compound possible; no matter in what position the substitution takes place, the product must be the same. As seen in the preceding formula (carbolic acid), the hydroxyl (O H) substitution takes place in the first position, but the product would be the same if it were to take place in any of the other five positions. While this is true of the monosubstitutions of benzol, the disubstitutions are capable of forming three different compounds, identical in chemical composition but very different in their physical properties.

A knowledge of the relation, constitution, and properties of these substances is indispensable to an intelligent appreciation of their usefulness and application; and, as all the so-called phenols possess, in a greater or less degree, antiseptic properties upon which their value in surgical science as well as preventive medicine depends, I may be pardoned for thus alluding to some recently developed facts in their chemistry, in this connection.

Naphthols are the hydroxyl substitutions of naphthalin, and are two in number, commonly known as Alpha- and Beta-naphthol. These are made by heating naphthalin with sulphuric acid. Alpha-naphthol is formed when 60° to 90° C. is reached, and Beta-naphthol at from 180° to 190° C. The Alpha- or Beta-naphthalin-monosulphonic acid thus formed is treated with sodium hydrate, and is decomposed into sodium naphtholate, sodium hydrate, and sodium sulphite. Naphthol is obtained from the sodium naphtholate by decomposing it with hydrochloric or sulphuric acid; it is then purified by distillation.

Hydronaphthol is a derivative of the hydroxyl substitution of naphthalin, which latter of itself possesses antiseptic properties of sufficient value to have already excited notice and a desire to learn more of its compounds. The term "hydronaphthol," although perhaps not, strictly speaking, correct, yet conveys sufficiently well its character and relations to naphthalin, and at the same time is a convenient term for every-day use. It has been but recently discovered that it possesses antiseptic properties, and the claim is made that it is from ten to fifteen times more efficient than carbolic acid. It is the most promising antiseptic of the phenol series, and, besides, possesses so many other advantages over substances now used for this purpose that it bids fair to supersede many of these. In surgical practice it will take the place, probably, of carbolic acid. Of

the many new members of the phenol series which have been discovered since Calvert called attention to carbolic acid about thirty years ago, and which have been utilized in the industrial arts, some are better antiseptics than the latter. With but one or two exceptions, however, none have obtained any prominence as germicidal agents. Carbolic acid, though a fairly reliable antiseptic in strong solutions, when so used, involves some risk to life, from its corrosive action upon animal tissues and well-known poisonous properties. In weak solutions it is exceedingly unreliable, and its disagreeable odor often hides that of putrefaction, instead of preventing the occurrence of the latter. On the other hand, hydronaphthol is non-irritant, non-poisonous, and non-corrosive; and, although only soluble in water to the extent of one part in one thousand, in this proportion is antiseptic. It has no odor to disguise that of putrefaction, nor is it decomposed or rendered inert by the products of putrefactive decomposition—such as sulphureted hydrogen, ammonia, etc. It is far more stable than carbolic acid, not being volatile at ordinary temperature. Its vapor, when volatilized for purposes of fumigation, has no obnoxious effect upon the organs of respiration. It will not injure, either in substance, solution, or vapor, colors or textile fabrics. Its sparing solubility in water is rather an advantage than otherwise, as mistakes in making solutions can not occur. A saturated solution is about of the strength of one to one thousand, and in this proportion it will perfectly preserve for an indefinite time animal tissues and fluids, and yet upon living tissues this solution produces no perceptible effect other than the formation of a very slight albuminate film—this latter to be considered rather an advantage than otherwise, inasmuch as it constitutes an additional security against infectious germs floating in the air. If for no other reason than that it is non-corro-

sive, and hence will not injure the polished surface and keen edge of cutting instruments, it is to be preferred to mercuric bichloride, and to the latter it is second only in antiseptic qualities. It has a slight aromatic taste and odor, and crystallizes in scale-like clinorhomboid laminæ of a silvery white or grayish hue. Although but sparingly soluble in water, it dissolves freely in alcohol, ether, chloroform, glycerin, benzole, and the fixed oils. It is not volatile at ordinary temperature, but begins to sublime at about 90° C. With the alkalies and the alkaline earths it forms compounds which are unstable, are readily decomposed by carbonic acid, and of doubtful antiseptic value. It is easily powdered, and in this condition, triturated with carbonate of magnesia, silicates, such as fuller's earth, China clay, etc., in the proportion of two parts of the hydronaphthol to one hundred of either of the above named, can be dusted along the line of incision and over the mouths of drainage-tubes, in the latter application having an advantage over iodoform, now so commonly used for that purpose, in that it does not dry up the serum escaping from the wound cavity, and thus block up the exit extremity of the tube. Absorbent gauze, cotton, jute, wood-flour, sawdust, peat, moss, and paper-wool may be impregnated with it by immersing them in its alcoholic or benzole solution and then drying; the hydronaphthol crystals cling to these without the aid of stearin, paraffin, or resin, as in the case of carbolic acid. As it is not decomposed by the presence of organic matter, it possesses this advantage over corrosive sublimate in the preparation of surgical dressings. Its ten-per-cent. alcoholic solution perfectly sterilizes silk, and sufficiently hardens and preserves, as well as sterilizes, catgut.

In order to satisfy myself as to the solubility of this compound, observations having in view the determining of this point with some degree of accuracy gave the follow-

ing: In hot water it will dissolve in the proportion of one part in a hundred, and a residue of an oily or tarry substance occurs, which latter, upon boiling the solution, melts and floats about on the surface. If the water be only warmed to a temperature of 70° C., the residue is found at the bottom of the flask. Upon filtering the solution and allowing the filtrate to cool to 17° C., the excess of hydronaphthol crystallizes, leaving a solution of the strength of 1 to 800. By reducing the temperature still lower, or by vigorous shaking, a further quantity is thrown down, leaving a solution of the strength of 1 to 1,100, which latter remains permanent.

It dissolves in cold water to the extent of one part of the hydronaphthol to two thousand parts of water. To effect this, however, it is necessary that it should remain in contact with the water, or be occasionally agitated. The clear filtrate from this solution has the characteristic taste of hydronaphthol and possesses antiseptic properties.

To test for the presence of the hydronaphthol in solution, add a few drops of the solution of the subacetate of lead, when a white precipitate will be thrown down. Or the addition of chloride of sodium to the solution will cause its separation in a fine white precipitate, giving the liquid a milky appearance.

The tarry material which floats about in a melted condition upon the surface of the hot solution is probably alpha-naphthol, an impurity which will, no doubt, be gotten rid of in the course of a further experience in the manufacture of the compound. It does not interfere with the antiseptic qualities of the solution, nor does it do other harm, as far as is at present ascertained.

In order to ascertain to what extent hydronaphthol could be relied upon to prevent the occurrence of putrefactive

changes in animal tissues and fluids, the following preliminary observations were made:

First, three solutions were prepared for use, the first containing 1 gramme of hydronaphthal in 1,000 grammes of warm water, the second containing 1 gramme in 1,500 grammes of water, and in the third 1 gramme in 2,000 grammes of water. In all of these solutions fresh animal tissue (beef) was placed, and, to afford a control test, a piece of the same beef was placed in a similar flask containing pure water, and all of the tests were exposed to a temperature of about 21° C. in an ordinary room, and as nearly as possible to the same general conditions, with the following results: At the end of twenty-four hours the flask containing the beef and water only showed signs of decomposition, and in the course of another twenty-four hours had broken down completely. The other three flasks, after one hundred and twenty hours' exposure, were found to have undergone no change, and were in a perfect state of preservation.

As beef solution is the medium generally employed for the purpose of testing the power of antiseptic substances, the following experiments were made: The beef solution was first filtered while hot, and then solutions of hydronaphthol made in this vehicle. In the first 1 gramme of hydronaphthol was dissolved in 1,000 grammes of the warm beef solution, in the second 1 gramme was dissolved in 1,500 grammes, and in the third 1 gramme was dissolved in 2,000 grammes. A control test was likewise prepared in the same manner, but without the addition of the antiseptic. These were all placed under the same conditions, as to temperature, etc., as in the preceding experiments, with the following results: At the end of twenty-four hours the control test began to exhibit some turbidity, and before forty-eight hours had elapsed indubitable signs of advanced decomposition were present. All three of the solutions

containing the hydronaphthol, however, at the end of one hundred and twenty hours, were found in their normal condition.

The addition of 1 part of the antiseptic to 1,000 parts of fresh urine has maintained the latter in a perfect state of preservation for four months, and probably will continue to do so indefinitely. Solutions of glue and gelatin, so prone to decomposition, have been preserved by the addition of the antiseptic in the proportion of one twentieth of one per cent. throughout the warm summer months, and in the same proportions the formation of mold or mildew was prevented in such moist organic compounds as mucilage, starch and glue pastes, dyewood and other extracts.

The results of these observations encouraged me to seek still further light upon the subject of the antiseptic properties of hydronaphthol, and to ascertain to what extent its preservative powers could be carried, and to likewise determine if these depended upon a germicidal action on the one hand, or upon a simple inhibition of the growth of bacteria on the other. With this end in view, I sought the assistance of Dr. G. M. Sternberg, the well-known authority upon disinfectants and antiseptics. That gentleman was about to sail for Europe to be gone for a period of six months or longer, but proffered me the services of his first assistant, Dr. Abbott, at the laboratory of the Johns Hopkins University, in Baltimore. These I gladly accepted at once, and during the past three weeks experiments having the object of determining the following points have been carried on: First, its germicide value on broken-down beef-stock containing pathogenic spore-bearing organisms, micrococci, and putrefactive bacteria; second, its value in destroying pure cultures of anthrax and pure cultures of pathogenic micrococci; and, third, its value as an antisep-

tic (the prevention of development without killing the organisms).

In the first place, the insolubility of the hydronaphthol was found to be an insuperable bar to any germicidal action in its normal solution (0·1 per cent.). A mixture was therefore made of 1 gramme to 100 c. c. of water (1·0 per cent.), this being about ten times above saturation. This mixture was tried on putrefied beef-tea containing putrefactive and pathogenic organisms and spores, on anthrax pure, on subtilis pure, and on pure cultures of pathogenic micrococci. To these it was added in equal proportions—that is to say, ten cubic centimetres of the substance to be disinfected and the same quantity of the one-per-cent. mixture of hydronaphthol were added together. This gave five tenths of one per cent. (0·5 per cent.) of the hydronaphthol present, being five times above saturation. A drop of the fluid containing the organism was, after two hours' exposure, introduced into the flasks containing sterilized solution of beef peptones, the culture medium generally used in disinfectant experiments, and, after the standard length of time of exposure in the incubator (two hours), in all the tubes the respective organisms were found to be present. This showed that when the substance was present in a mixture five times above saturation it was not germicidal to these organisms and spores. These experiments seemed to at once settle the question as to its germicidal powers.

In order to test its power as an antiseptic, the following experiments were made: Eleven flasks were prepared, each containing 100 c. c. of solution of beef peptone, to which hydronaphthol was added in the following proportions: 1 to 100, 1 to 500, 1 to 800, 1 to 1,000, 1 to 2,000, 1 to 4,000, 1 to 6,000, 1 to 8,000, 1 to 10,000, 1 to 16,000, and a flask in which none of the antiseptic was placed. These were inoculated with two drops of decomposed beef-tea,

and placed in the incubator. The flask put up for comparison, and which contained none of the hydronaphthol, broke down completely in twenty-four hours. The other flasks, from the strongest up to the 1-to-6,000 solution, and including the latter, after one hundred and twenty hours' exposure in the incubator, resisted the development of decomposition, the first failure taking place in the 1-to-8,000 flask.

The following is a summary of these experiments:

1. As a germicide it failed to disinfect decomposed beef-tea containing pathogenic organisms and spores when present in 0·5 per cent. 2. It failed to prove germicidal to pure anthrax, pure subtilis, and pure micrococci, in the same strength. 3. As an antiseptic it proved to be active in arresting the development of the bacteria in the proportion of 1 to 6,000, and failed only when the 1-to-8,000 solution was reached.

That the value of an antiseptic agent does not necessarily depend upon its germicidal powers is a well-established fact;* it is further well known that some agents of well known germicidal power are inapplicable as antiseptics. To the class of agents which prevent or arrest putrefactive changes, without necessarily destroying the organism upon which these changes depend, but rather whose potency is attributable to their influence in holding in check their development, Lister has given the name of "inhibitory" agents, or antiseptics having an "inhibitory action."†

The importance of this distinction can not be overrated, for it has been the custom in the past to use the words "germicidal," "disinfectant," and "antiseptic" in a loose manner, and, in some instances, as synonymous terms. The

* Koch, "Mittheilungen des Kaiserlichen Gesundheitsamtes," Band i, Berlin, 1881.

† "British Medical Journal," October 25, 1884, p. 804.

impropriety of this is at once obvious, and it is now growing to be the custom to speak of such substances as are both germicidal and antiseptic as simply germicides or disinfectants; while those which are antiseptic without possessing the power of killing organisms endowed with a peculiarly tenacious hold upon life, such as those of anthrax and pathogenic micrococci, are called simply antiseptics. For the present, this distinction will perhaps be the best attainable, with our present want of knowledge of the life-history of these lower organisms. For instance, Sternberg * asserts, and there can be no reason for questioning the opinion of this authority, that "the vital resistance of bacterial organisms to chemical reagents differs, within certain limits, for different species." Hence, unless some standard of vitality, so to speak, were established, different observers would use the distinctive terms "disinfectant," "germicidal," and "antiseptic" with different meanings, and no end of confusion would result. It is perhaps best, therefore, that the term germicide or disinfectant should be limited to such agents as will destroy reproductive spores, inasmuch as these possess powers of resistance far in excess of bacterial organisms in which active development takes place by the process known as "multiplication by fission."

Taking, therefore, the reproductive spores, such as those of the anthrax bacilli, as the standard for the test of strength of a germicide, very few of the agents supposed to be active germicides are found to be efficient in solutions which would be safe to employ in practical surgical work. The most notable exception to this will be found in corrosive sublimate, and, as elsewhere shown, this agent is not a stable antiseptic. But, when the next most popular antiseptic, carbolic acid, is brought forward for comparison, its impracticability for general use as a germicide will be at once

‡ "American Journal of the Medical Sciences," April, 1883, p. 334.

apparent when the statement is made, upon the authority of Koch,* that, for the certain destruction of the spores of the anthrax bacilli, an aqueous solution of carbolic acid of the strength of 1 to 10 is necessary. This, for purposes of application in wound treatment, is manifestly impracticable.

The well recognized rule†—that "*The effect which a substance introduced into a wound as an antiseptic may have on the exposed surfaces of the wound must be taken into consideration in choosing one for use, as well as its effect upon the germ supposed to be present*"—has a direct bearing upon the question at issue.

Of all the substances which are at present known to have an inhibitory action upon bacteria, and hence are in the true sense antiseptic, with the sole exception of corrosive sublimate, hydronaphthol is the most powerful. By reference to the following table, adapted from Sternberg by Pilcher,‡ showing the comparative value of the agents named in their power to arrest the development of the micrococcus from pus, this claim will find undeniable corroboration. According to Sternberg, the other organisms of this class, bacteria termo, etc., are inhibited by about the same strength of antiseptic as that necessary for pus micrococci, and therefore this table may be cited for purposes of comparison:

TABLE OF MINIMUM STRENGTHS OF ANTISEPTIC AGENTS REQUIRED TO INHIBIT GERM-DEVELOPMENT.

Antiseptic agent.	Efficient in the proportion of one part to
Mercuric bichloride	35,000
Iodine	4,000
Sulphuric acid	1,800
Carbolic acid	500

* "Mittheilungen des Kaiserlichen Gesundheitsamtes," etc., p. 236.

† Pilcher, "The Treatment of Wounds," New York, 1883.

‡ Ibid.

Salicylic acid and sodium biborate, equal parts	200
Boric acid	200
Ferric sulphate	200
Sodium biborate	100
Alcohol	10

According to the experiments above detailed, hydronaphthol is efficient in the proportion of between 1 to 6,000 and 1 to 8,000, and in the table just quoted would occupy the position next to mercuric bichloride. In other words, as an antiseptic it is about one fifth as powerful as the mercuric bichloride; from one and a half times to double the strength of iodine; four times as strong as sulphuric acid; *at least twelve times as efficient as carbolic acid; thirty times as potent as salicylic acid*, when sodium biborate is added to the latter (for the purpose of increasing its solubility) in the proportion of equal parts of each; *thirty times as powerful as both boric acid and ferric sulphate;* sixty times as strong as sodium biborate, and *six hundred times as strong as alcohol.*

In making solutions for surgical use, it is my custom to add a sufficient quantity to a teacupful of hot water to supersaturate the same; this produces a milky mixture. Sufficient water at the ordinary temperature is then added to this to make it a clear solution. Or powders of seven grains and a half each, or compressed tablets containing the same quantity, may be at once dissolved in a pint of warm water. The latter would constitute a convenient and portable form for use in private practice. In my hospital service, the irrigator jars are kept about two thirds full of the solution, having an excess of the hydron phthol at the bottom. By adding a quantity of hot water to the solution just before it is required for use, a super-saturated solution is at once obtained. After the solution has been for a few days in contact with the excess at the bottom of the jar, the

latter precaution may be found to be unnecessary. The saturated solution may be used for washing the site of operation, the surgeon's hands and those of his assistants after scrubbing with mercuric bichloride solution in case of suspected infection; for saturating towels for the purpose of isolating the field of operation; as a bath for the instruments; for washing the sponges and for irrigating the wound.

In the preparation of silk and catgut it would be safest, especially in the case of the latter, to first immerse the gut, wound upon glass or hard-rubber spools, in Kümmel's solution of mercuric bichloride (one half of one per cent.) for twelve hours, and then preserve it permanently in a one-per-cent. alcoholic solution of hydronaphthol. Silk may be boiled in the first-named watery solution of sublimate and kept, for protection, in the hydronaphthol alcoholic solution as used for the gut. This method of sterilizing catgut and silk I prefer to all others as being the safest. It has been asserted by its originator that it will afford perfect protection against infection, even though the gut be made from an animal dead of anthrax. I am particular in making this statement here in order to qualify a remark concerning the sterilizing of gut by means of hydronaphthol, made in the first portion of this article. I also prefer to trust to the well-known germicidal power of a freshly prepared solution of sublimate in the first preparation of sponges, as well as their subsequent purification after an operation, where they are used more than once. But they can be kept with advantage in the hydronaphthol solution, after sterilizing, until needed for use. So also with horsehair for sutures and drains, and rubber drainage-tubes; after sterilizing in mercuric-bichloride solution, the hydronaphthol solution, from its reliability and absence of tendency to decompose, will be found far preferable for purposes

of permanent preservation. I am led to emphasize this statement by the fact that it has happened to me recently to find sponges, placed in a 1-to-1,000 solution of corrosive sublimate—which latter at first was certainly germicidal—after a few weeks developing a most sickening, putrid odor, and to afford other evidences of having undergone putrefactive changes, even showing a well-marked growth of mold upon the surface of the solution in the screw-capped fruit-jar in which they had been placed. This can only be attributed to the want of stability of the bichloride solution and the decomposition of the sublimate in the solution into the submuriate, a very feeble as well as insoluble disinfectant. This can not happen in the hydronaphthol solution, as the latter remains without change for an indefinite time (so far as can at present be ascertained), as well as preserves, against putrefactive changes, organic substances of whatever nature, particularly if these have been previously subjected to the germicidal action or sterilization of such a potent agent as a freshly prepared solution of corrosive sublimate.

When a spray is used, a solution of the strength of one per cent. in alcohol may be used in the reservoir of the atomizer. This, when mingled with the steam from the boiler of the instrument, can be diffused in the atmosphere with advantage where it is considered that a spray adds to the thoroughness of the antiseptic measures.

The softness of the crystals of hydronaphthol and the facility with which they cling to the meshes of gauze, cotton, jute, etc., render the substance peculiarly well adapted for incorporation in these materials for the purpose of rendering them permanently antiseptic for surgical purposes. Messrs. Seabury & Johnson, of New York, have made, at my request, gauze and cotton dressing containing twenty per cent. of the antiseptic, and I can testify to their efficiency and reliability.

Cushion dressings of wood-flour, paper-wool, and sawdust are used in my hospital service almost exclusively; these can be readily saturated with a warm solution of hydronaphthol in water of the strength of 1 to 500, in which also mercuric bichloride is dissolved in the same proportion. The bichloride in this solution will be sufficiently germicidal to destroy any possible source of infection, and the hydronaphthol will furnish the permanent antiseptic. No chloride of sodium need be added to the solution for the purpose of preventing the decomposition of the corrosive sublimate, as the latter will be sufficiently stable to perform its office of sterilizing the dressing, and, when this is accomplished, it is of no further use, and, in fact, will soon be converted into calomel.

After saturating the wood-flour, sawdust, or paper-wool with the above-named solution, the two former should be spread out to dry in a place free from dust. If an alcoholic or benzole solution be used, drying will go on rapidly and but slight risk be encountered of the materials becoming again infected by any possible floating germs in the air. In the case of paper-wool, the drying may be facilitated by running the material through a clothes-wringer. Should the sawdust or wood-flour dry in lumps, as it is apt to do when the watery solution is used for impregnating, these may be readily broken up by rubbing them through a common flour-sieve. When an alcoholic or benzole solution is used for the purpose, no such after-treatment of the wood-flour or sawdust is necessary.*

It is sometimes thought to be good practice to dust along the line of incision some absorbent powder possessing antiseptic properties. For this purpose I have found

* The addition of a small proportion of glycerin to the solutions used for impregnating the wood-flour and sawdust will prevent the tendency of the latter to fly about when handled.

carbonate of magnesia, having triturated with it the hydronaphthol in the proportion of 2 to 100, a very desirable and efficient substitute for iodoform.

At my request, Mr. Max Schwarz, of New York, Superintendent of the Technical School for Brewers, known as "The First Station of the Art of Brewing," etc., and late a pupil of Prof. F. Cohn, of Breslau, Germany, made the following experiments upon the antiseptic powers of hydronaphthol at his laboratory:

In the first instance the following incubation liquid was prepared, viz.:

Distilled water.....	1 litre;
Chemically pure grape-sugar.....	100 grammes;
Potassium phosphate.....	30 "
Ammonium nitrate.....	30 "

This was sterilized by boiling for thirty minutes.

This liquid was divided in ten equal parts as follows:

Part	I,	containing	no	hydronaphthol.				
"	II,	"	1	part	in	9,000	parts	of the liquid.
"	III,	"	1	"		8,000	"	" "
"	IV,	"	1	"		7,000	"	" "
"	V,	"	1	"		6,000	"	" "
"	VI,	"	1	"		5,000	"	" "
"	VII,	"	1	"		4,000	"	" "
"	VIII,	"	1	"		3,000	"	" "
"	IX,	"	1	"		2,000	"	" "
"	X,	"	1	"		1,000	"	" "

Of each of these above-named liquids four equal parts were incubated in the following sequence, after all had been sterilized by boiling beforehand, with the germs of the following fungi:

Penicillium glaucum,
Mucor mucedo,

Aspergillus niger,
Sterigmatocystis nidulans.

After incubation these culture-liquids, forty in number, were placed in an air water-bath (incubator) which was kept at a temperature of 24° C. for forty-eight hours. After the lapse of this time a strong fungoid growth could be perceived in all the control tests, which latter, of course, did not contain any hydronaphthol, while all the liquids containing hydronaphthol had remained clear and free from fungoid growth, and remained so for more than five days, when they were disposed of.

These experiments prove that hydronaphthol, in proportion of 1 to 9,000, prevents the development of these germs. Even more diluted solutions of hydronaphthol may possess antiseptic action, but exact observations have yet to be made in order to ascertain the limit of its antiseptic power. This, of course, would be of highly scientific interest, but for practical purposes the above given proportion of 1 to 9,000 may be sufficient in all cases where inhibition of the germs of this class is desired.

A second series of investigations into the antiseptic properties of hydronaphthol was conducted as follows.

To each of the above-named solutions the compound was added as follows:

1 part of hydronaphthol in 9,000 parts of the solution.
1 " " " " 8,000 " " "
1 " " " " 7,000 " " "
1 " " " " 6,000 " " "
1 " " " " 5,000 " " "
1 " " " " 4,000 " " "
1 " " " " 3,000 " " "
1 " " " " 2,000 " " "
1 " " " " 1,000 " " "

and a control-test, free from hydronaphthol.

After careful sterilization by means of boiling, to these were added three cubic centimetres of a suspension of the best, purest, and healthiest beer-yeast (*saccharomycis cerevisiæ*); these were well agitated, and then kept quiet for four days, all being well protected from the germs floating in the atmospheric air by closing the mouths of flasks containing these liquids with sterilized cotton-wool.

After four days' standing, about one tenth of each o these liquids was distilled off separately, and the ten different distillates tested for alcohol by addition of a solution of iodine in a potassium-iodide solution rendered alkaline by means of potassium hydrate.

After twenty-four hours' standing the precipitates thus formed were examined under the microscope, and the following results obtained:

In the distillate of the solution containing no hydronaphthol, iodoform was found.

In the distillate of the solution containing

1 part hydronaphthol to 9,000, iodoform was found.
1 " " " 8,000, " " "
1 " " " 7,000, " " "
1 " " " 6,000, " " "
1 " " " 5,000, " " "
1 " " " 4,000, " " "
1 " " " 3,000, " " "
1 " " " 2,000, no iodoform was found.
1 " " " 1,000, " " " "

From these experiments the conclusion is to be drawn that 1 part of hydronaphthol dissolved in 2,000 parts of a solution which, under ordinary circumstances, ferments readily with yeast, is capable of holding in check this fermentation. Microscopic examination showed that in the liquids containing hydronaphthol in the proportions of 1 to 1,000 and 1 to 2,000, the yeast-cells presented the appear-

ances of a coagulated protoplasm, while those in the other liquids showed a good and healthy protoplasm.

The foregoing experiments confirm the observations made at the Johns Hopkins University laboratory concerning the inhibitory antiseptic effect of this compound. The hope that a positive germicide effect may yet be demonstrated is suggested by the results of these observations and the extremely dilute solutions found to be efficient in the inhibiting of these organisms.

The following series of cases is herewith presented, comprising my experience up to the present date, in the practical application of hydronaphthol to surgical practice. Some interesting points are worthy of mention, among others the fact that the application of the powder directly to the skin was not without some disadvantages, in that it produced irritation, and in two cases, at least, was responsible for a failure to secure union by first intention. These cases, however, continued to pursue an aseptic course. When the hydronaphthol was diluted in a two-per-cent. trituration with carbonate of magnesia, this feature was no longer noticeable, and the value of the new antiseptic was fully demonstrated.

Case I.—*Floating Body in Knee Joint.*—Mrs. G., aged fifty-six, for several years past has suffered from sudden pain in knee joint, especially while ascending or descending a stairway. This was followed frequently by an attack of synovitis. Recently these attacks have recurred with increasing frequency, and she became clamorous for relief. Examination revealed the presence of a floating body in the joint. On September 14, 1885, I opened the joint, having failed in an attempt to fix the body for the purpose of cutting down directly upon it. I passed my finger into the interior and searched for and removed the body. It proved to be of the shape and character usually found under these circumstances, and of about the size of a hazel-nut. The joint was thoroughly irrigated with a warm solution of hy-

dronaphthol, 1 to 1,000, a few strands of catgut introduced for purposes of drainage, the wound closed with a continuous catgut suture, pure hydronaphthol dusted over the wound, a sawdust cushion which had been saturated in a hot alcoholic solution of hydronaphthol and then dried was then bandaged over the wound, a well-padded back-splint applied, and the patient placed in bed. No pain, fever, nor other untoward circumstance occurred to give me any uneasiness in this, my first case of importance in which the new antiseptic was used. At the end of fourteen days I removed the dressings for the first time, flexed the limb at a right angle, and in a few days the patient was walking about—well. There was an excoriated spot near the line of union, which a subsequent experience led me to believe that the hydronaphthol, applied as it was in its undiluted state, was responsible for.

Case II.—*Excision of Entire Radius.*—E. I., aged nine and a half. Osteo-myelitis of the left radius. Operation September 14th, at St. Mary's General Hospital. Incision entire length of radius, upon outer and posterior aspect of arm. Bone sawed through middle with chain-saw, and each half separated from periosteum and removed. Hydronaphthol solution, 1 to 1,000, used for irrigating; drainage-tube of soft rubber placed in position; sutures of catgut; pure hydronaphthol dusted along line of sutures and wood-flour dressing applied. Dressings first changed, on account of profuse discharge, on eighth day. Edges of wound united at intervals, primary union taking place, perhaps, in the aggregate, in about one half of the length of the incision. The skin about the points where union had not taken place was red, and in spots presented an excoriated appearance; this latter being due, no doubt, to the pure hydronaphthol dusted upon the edges of the cut surfaces. The wound was irrigated as before and redressed, and healing thereafter proceeded without interruption. No rise of temperature after third day.

Case III.—*Wry Neck; Open Section of Sterno-cleido Mastoid.*—M. S., aged eight. Wry neck resulting from measles four months ago. Sterno-cleido mastoid contractured. September 18th made section of the muscle, both at its clavicular and sternal attachments; irrigated with hydronaphthol solution;

catgut drains and utures. Dusted hydronaphthol and carbonate of magnesia (two parts to one hundred) along line of incision; dressed with wood-flour sterilized with corrosive sublimate, and rendered antiseptic by hydronaphthol. Head retained in position by plaster-of-Paris dressing, including chest, shoulders, and head. No fever, pain, nor other disturbance. Entire dressing removed on twentieth day. Wound healed perfectly; no pus.

Case IV.—*Wood's Operation for Radical Cure of Hernia.*—E. M., aged fourteen. Inguinal hernia, left side, of several years' standing. Has tried many trusses, but, owing to sensitive skin and extremely nervous condition of child, were abandoned. The parents solicited an operation for his relief. September 23d, operation of Mr. John Wood performed. Silver-wire suture. Hydronaphthol solution, 1 to 1,000, used for irrigating. Wound in scrotum left open; dressings of wood-flour and hydronaphthol applied. No fever nor other cause for anxiety. Wire and last dressings removed on fifteenth day. Needle punctures closed in twenty-four hours; wound in scrotum granulating in a healthy manner. Ointment of hydronaphthol (℥ ss. to ℥ j) ordered for latter. Discharged, cured, on twentieth day.

Case V.—*Ligature of Femoral Artery for Elephantiasis.*—Mrs. C., aged forty-eight, admitted to hospital September 23d. Elephantiasis arabum of both lower extremities below knee joint of four years' duration. Patient an opium *habitué*. Operation of ligature of femoral above profunda on September 24th. Irrigation by means of hydronaphthol solution, 1 to 1,000. Pure hydronaphthol sprinkled along line of sutures. Wood-flour-cushion dressings and a spica bandage applied. No fever, but dressings had to be removed on fourth day on account of profuse serous discharge. Skin along line of sutures irritated and in some places excoriated. Union for about one third of the length of wound only; deeper portions of wound united. Dressed thereafter with an ointment of hydronaphthol (℥ ss. to ℥ j). Granulating healthily.

The limb was at first cold and of a yellowish gray color; in a few hours it became warm. In eight days it was found to

have been reduced in size fully one third. Case still under observation.

Case VI.—*Strangulated Hernia; Operation.*—E. W., aged seventeen. Right inguinal hernia had existed for several years; for last two or three years had worn no truss. Hernia had not been reduced completely for four months. Admitted to St. Mary's General Hospital, September 24th. When seen by me was in acute general peritonitis, fæcal vomiting, knees drawn up, countenance drawn and anxious, pulse small and thready, surface cold and clammy. Symptoms of strangulation had existed for six days prior to admission. Stimulated freely; three hours later herniotomy performed; sac opened; gut believed to be yet in good condition, so far as could be ascertained. Large mass of omentum excised, and some portions adherent to canal were brought up and stitched with catgut to internal ring with neck of the sac. Hydronaphthol, 1 to 1,000, used for irrigating, and pure powdered hydronaphthol dusted along line of incision; wood-flour dressings applied. Patient rallied after vigorous stimulation. Dressings removed on fourth day, owing to their becoming disarranged by restlessness of patient. Deeper portions of wound found to be healed. Integumentary margins were found to have been irritated, swollen, and gaping. Sutures of catgut had softened by the copious exudation from the wound edges, and had given way. Granulation went rapidly on; peritonitis rapidly subsided; bowels moved spontaneously on the seventh day. Patient sat up on the twenty-first day. The wound rapidly granulated under the application of hydronaphthol ointment (ʒ ss. to ℥ j).

Case VII.—*Perforating Wound of the Elbow Joint.*—J. C., aged eight. Upon the evening prior to applying at my office, September 24th, while reaching up to unlatch an area-gate, his foot slipped from the stone step, and his left arm was caught upon one of the iron pickets of the gate. He called for assistance, and his mother lifted him from the sharp iron rod upon which he hung. A ragged wound was found upon the inner border of his arm, near the posterior surface. A dressing of vaseline was applied. The boy complained greatly of pain, and the following morning he was brought to my office. The joint

was very much swollen, hot, and tender. Synovial fluid was escaping from the wound. A probe, passed along the wound track, entered the joint midway between the inner condyle of the humerus and the olecranon process of the ulna. Pulse 130, temperature 102½°. Wound surroundings and joint irrigated for several minutes with warm solution of hydronaphthol, 1 to 1,000, drainage-tube introduced, parts dusted with hydronaphthol and magnesia (2 to 100). Paper-wool and hydronaphthol dressing and trough-splint applied. In twenty-four hours temperature reduced to 99°; pulse to 80. Pain had entirely disappeared. Dressings removed on the fourth day for the purpose of removing the drainage-tube; for this latter catgut drains were substituted. Arm was found to be normal in size and appearance. On the fourteenth day following the injury the dressings were again removed, when the wound was found to be healed, with complete movement in the joint.

Case VIII.—*Osteo-sarcoma of Tibia.*—Mrs. M., aged fifty-four. Blow upon middle third of left tibia about four months prior to operation. Admitted to St. Mary's General Hospital, October 2d. Large mass of broken-down sarcomatous growth (fungous hæmatodes) upon anterior aspect of tibia, at about its middle. Amputation at knee joint performed October 5th by lateral-flap method. Hydronaphthol irrigation (1 to 1,000); rubber drainage-tube; hydronaphthol and carbonate of magnesia (2 per cent.) were well triturated together and dusted along line of sutures. Dressings of wood-flour cushions applied. No rise of temperature, pain, nor other inconvenience. Dressings not disturbed until tenth day. Parts aseptic; drainage-tube removed; union perfect; no irritation. Cushion of wood-flour reapplied to small opening through which drainage-tube had emerged.

Case IX.—*Compound Fracture of Leg.*—T. W., aged eight, school-boy. Brought in by ambulance October 8th. Heavy truck-wheel had passed over his left tibia and fibula at the junction of the upper with the middle third. Wound leading down to fibula admitting my index-finger; another over tibia, about an inch and a half long. Surrounding parts and wound itself thoroughly washed and deeper portions irrigated with hydro-

naphthol solution, 1 to 1,000. Several strands of catgut were passed from bottom of each wound through the soft parts; hydronaphtholated magnesia and wood-flour cushion dressings applied; limb supported in a wire-cloth splint and suspended. No pain since dressings were applied; slight fever at end of first twenty-four hours, which subsided in a few hours without any treatment. Primary dressings still *in situ* at present writing (October 19th, eleventh day), and these will not be disturbed, unless some special indications exist, until bony union is believed to have taken place.

Case X.—*Supra-condyloid Osteotomy for Genu-varum.*—Rosie K., aged thirteen. Three months previously I performed excision of the knee joint for tubercular osteitis of the inner femoral condyle and head of tibia. Owing to extremely thin shell of bone left after gouging out with Volkmann's sharp spoon cancellous tissue of condyle and head of tibia, good apposition of the parts was not obtained, and, when the dressings were finally removed, the limb was found to be in the position of genu-varum. To correct this, a supra-condyloid osteotomy, after the manner of Macewen, was done on October 8th at the hospital. The incision, however, was made upon the outer instead of the inner border of the thigh. Catgut drain inserted; wound sutured; hydronaphthol in carbonate of magnesia (2 per cent.) dusted along line of sutures; wood-flour cushion dressing and plaster-of-Paris splint applied. No fever, pain, nor discharge has occurred up to present writing (October 19th). It is not expected that the dressings will be removed in this case until union of bone is believed to be complete.

Case XI.—*Fibrous Tumor at Site of Pre-trochanteric Bursa.*—J. H., aged forty-seven, Egyptian sailor. Admitted to hospital on account of growth over right trochanter. Fell from rigging of vessel some years ago and received an injury to the bursa in this region, which led to suppuration. Since then there appeared the present growth, which has grown slowly, and of late has occasioned him some inconvenience, and at times been tender and painful. Operation of excision October 8th; hydronaphthol solution, 1 to 1,000 for irrigation, etc.; catgut drains. Hydronaphtholated magnesia (2 per cent.) and

wood-flour cushion dressings held in position by spica. Dressings found disarranged, and therefore changed on fourth day. Union progressing along entire line of incision; no irritation or discharge; case thus far afebrile and painless (eleventh day).

The following is a *résumé* of the antiseptic methods employed in this hospital with hydronaphthol:

Preparation of Sponges.—Medium-sized sponges of good quality are selected and thoroughly beaten so as to break up and loosen all calcareous particles. These are thoroughly washed until all gritty matter is separated. They are then placed in a solution of permanganate of potassium of the strength of thirty-six grains to the pint, and there allowed to remain for a few minutes, or until they are of a brown color. They are then washed in clean water and placed in a bleaching solution made as follows:

Sodium hyposulphite.....	10 ounces;
Water	68 "

Dissolve, and add muriatic acid, 5 ounces.

This solution should be made the day before required for use, so that the sulphur may separate from the solution. It should be decanted off. The sponges should be immersed in this solution for a few moments only. They should then be washed in clean water, and, in order to make certain that no sulphurous acid remains, it is well to immerse them a few moments in a solution of bicarbonate of sodium, 100 grains to the pint. They are then sterilized by being immersed in a 1-to-1,000 solution of corrosive sublimate for two hours. From this they are transferred to a 1-to-1,000 warm solution of hydronaphthol and kept hermetically sealed in a screw-cap fruit-jar or museum-jar. If it is desired to keep them in a dry state, glycerin should be added to the last-named solution, in the proportion of half an ounce to the pint, in order to prevent the sponges from

becoming harsh and brittle. For hospital use, a separate jar is kept for each day's supply of sponges, and, as soon as they are no longer required, they are washed thoroughly, again sterilized as before, and placed in the hydronaphthol solution in the jar in which they belong, which is numbered for purposes of identification, and not put to use again until at least a week has elapsed. This insures the most perfect immunity against infection from every source, and enables one to employ the same sponges again and again without incurring the slightest risk.

Irrigation.—During operations and dressings an almost constant stream of hydronaphthol solution, 1-3,000, in water previously sterilized by boiling, is kept running over the parts. The jar containing the irrigating solution is kept partly filled with the saturated solution, and, at the time of operating or otherwise employing the irrigating solution, warm water is added in the jar in sufficient quantity to reduce it to a weaker solution.* In cases of chronic joint disease or cases of hydrops articuli, if no purulent accumulation be present, the hydronaphthol is used to wash out the joint. If, upon tapping the joint, purulent or flocculent fluid flows through the cannula, a solution of corrosive sublimate is first used to thoroughly sterilize the interior, and this is, in its turn, well washed out with the hydronaphthol solution. By this means corrosive-sublimate poisoning is guarded against; a portion of the hydronaphthol solution may be left in the joint cavity. In all cases of a septic character sterilization had best be accomplished by the aid of the mercuric-bichloride solution, the latter being always washed away subsequently with the hydronaphthol solution.

* Solutions of from 1-3,000 to 1-5,000 are sufficiently strong for all purposes. The saturated solution, although generally well borne, has seemed at times to over-stimulate the tissues and lead to increased secretion, a very undesirable feature in any antiseptic agent.

Bath for Instruments.—The instruments are placed in shallow pans, porcelain-lined, and covered with a saturated solution of the compound. A towel, wrung out of the same, is spread out in a convenient place, upon which the operator drops the instruments when not in use, and from which an assistant transfers them to the bath until again needed. Towels for the purpose of isolating the field of operation are wrung out of a 1–1,000 mercuric-bichloride solution.

Preparation of Catgut.—The catgut should be wound upon hard-rubber, glass, or porcelain spools. It is then sterilized in a one-per-cent. solution of mercuric bichloride, being immersed for twelve hours. It is then transferred to an alcoholic solution of hydronaphthol, one tenth of one per cent., for permanent preservation. The latter hardens the gut sufficiently, and preserves it against all further change.

Silk and horse-hair may be treated in the same manner, excepting that they may be boiled in the corrosive-sublimate solution for a half hour and then immersed for twelve hours. They should be preserved in the alcoholic hydronaphthol solution, as in the case of the catgut.

Drains may be immersed in the corrosive-sublimate solution also, in the same manner as the catgut, and then placed, for permanent preservation, in a saturated watery solution of hydronaphthol, to which glycerin, in the proportion of half an ounce to the pint, has been added.

Wood-flour and Sawdust.—Sterilization of wood-flour and sawdust is accomplished by thoroughly triturating the same in a mortar with an alcoholic solution of corrosive sublimate, and in the same solution the hydronaphthol is dissolved, which latter gives to the dressing its permanent antiseptic character. The following is a good working formula for this purpose:

Hyd. bichlor., Hydronaphthol,	āā	3 ss.;
Glycerin		℥ j;
Spts. rectif.		Oj.

This should be triturated with 3 pounds of wood-flour, or finely-sifted sawdust, and, after drying, placed in bottles with large mouths until required for use. Bags are prepared, of different sizes, of coarse cheese-cloth previously rendered hygroscopic by boiling in a strong alkaline solution, and then washed and dried. The material known as mosquito-bar or netting, if used, need not be rendered hygroscopic, as its meshes are so coarse as to readily permit of the passage of the wound secretions through and into the wood-flour. These are dipped into the same solution prepared for the wood-flour or sawdust, before filling. They are prepared and filled upon the day of operation, and kept in a tin can, or wrapped in some impervious material until needed.

Absorbent Cotton.—This is used for backing up and placing around the edges of the cushion or pad dressings, when these are placed upon uneven surfaces. It is hydronaphtholated in an alcoholic or benzol solution, so that the former represents twenty per cent. of the cotton by weight.

Absorbent Gauze.—This is hygroscopic cheese-cloth; what is known among dry-goods dealers as archery bunting makes a very good dressing after being rendered hygroscopic. It is hydronaphtholated in the same manner as the cotton, and, after drying, kept in tin cans until needed for use. It is used principally for making bandages. Should it be designed for use in immediate contact with the wound, it is prepared in the same solution used for the wood-flour, in order to insure its thorough sterilization by means of the mercuric bichloride.

*Paper-wool.**—This is manilla tissue-paper, cut into strips one sixteenth of an inch wide and saturated with the same solution used for the wood-flour. It is passed through the rolls of a clothes-wringer, dried and carded, or pulled apart by hand. It is used as a cushion-dressing, or may be applied in a mass directly to the wound.

Hydronaphthol Soap.—Powdered soap, triturated with about four per cent. of hydronaphthol, is found to be most convenient for use. The compound may be incorporated in cakes of ordinary toilet soap with advantage. It is useful in scrubbing the parts preparatory to operation, the surgeon's hands, etc.

Hand Scrubbing-Brushes.—These are kept in a saturated solution of the hydronaphthol. Two sets are always at hand, one for cases in which some suspicion of sepsis is entertained and suppuration exists, and the other for aseptic cases and the surgeon's hands.

Mention has been previously made of a hydronaphtholated magnesia for use as an absorbent along the line of sutures. I think that this is uncalled for in the majority of instances, and in antiseptic surgery whatever is uncalled for had best be omitted. Wherever such an application is needed, this will be found a safe and efficient substitute for iodoform.

In addition to these, hydronaphthol incorporated in simple ointment, in the proportion of half a drachm to the ounce, is found to be an excellent application when a stimulating ointment is indicated. Old leg ulcers and the like are found to behave very kindly and heal rapidly under its use.

Dr. F. W. Rockwell, chief of our department of genito-urinary diseases, informs me that he has had some excellent experiences with hydronaphthol in cases of purulent cysti-

* See article in "N. Y. Med. Jour.," October 10, 1885.

tis, washing out the bladder once or more daily with a saturated solution. In a case of irritable bladder of long duration, in a female, I recently dilated the urethra so as to admit my index-finger, for exploratory purposes. An acute cystitis followed, which yielded readily to a daily irrigation with a warm solution of this compound.

A case of intractable eczema capitis recently yielded rapidly to the application of the hydronaphthol ointment. I believe the naphthols have been employed in the Vienna skin clinics for some time past with marked benefit.

To summarize the results of my experience thus far with this compound I would state that: 1. It is an efficient and safe antiseptic and anti-putrefactive agent. 2. This is accomplished in very dilute solutions; consequently it compares favorably in point of expense with carbolic acid, and it is especially as a substitute for the latter that its use is urged, not only on the score of cheapness, but of safety. 3. Its saturated solution is only of the strength of 1 to 1,100, and consequently no mistakes can occur in its use. In this strength of solution it is at least five times above its antiseptic limit, and yet is non-poisonous, non-corrosive, and, generally speaking, non-irritant.

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